JAMA Cardiology | **Original Investigation**

Income Disparities in Absolute Cardiovascular Risk and Cardiovascular Risk Factors in the United States, 1999-2014

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+ **Supplemental content**

IMPORTANCE Large improvements in the control of risk factors for cardiovascular disease have been achieved in the United States, but it remains unclear whether adults in all socioeconomic strata have benefited equally.

OBJECTIVE To assess temporal trends in 10-year predicted absolute cardiovascular risk and cardiovascular risk factors among US adults in different socioeconomic strata.

DESIGN, SETTING, AND PARTICIPANTS A cross-sectional analysis was conducted using data on adults 40 to 79 years of age without established cardiovascular disease from the 1999 to 2014 National Health and Nutrition Examination Survey.

EXPOSURES Socioeconomic status was based on the family income to poverty ratio and participants were divided into the following 3 groups: high income (family income to poverty ratio, ≥ 4), middle income (>1 and <4), or at or below the federal poverty level (≤ 1).

MAIN OUTCOMES AND MEASURES We assessed predicted absolute cardiovascular risk using the pooled cohort equation. We assessed the following 4 risk factors: systolic blood pressure, smoking status, diabetes, and total cholesterol.

RESULTS Of the 17 199 adults whose data were included in the study (8828 women and 8371 men; mean age, 54.4 years), from 1999-2014, trends in the percentage of adults with predicted absolute cardiovascular risk of 20% or more, mean systolic blood pressure, and the percentage of current smokers varied by income strata ($P \leq .02$ for interaction). For adults with incomes at or below the federal poverty level, there was little evidence of a change in any of these outcomes across survey years (cardiovascular risk $\geq 20\%$, 14.9% [95% CI, 12.9%-16.8%] in 1999-2004; 16.5% [95% CI, 13.7%-19.2%] in 2011-2014; $P = .41$; mean systolic blood pressure, 127.6 [95% CI, 126.1-129.0] mm Hg in 1999-2004; 126.8 [95% CI, 125.2-128.5] mm Hg in 2011-2014; $P = .44$; and smoking, 36.5% [95% CI, 32.1%-41.0%] in 1999-2004; 36.0% [95% CI, 31.1%-40.8%] in 2011-2014; $P = .87$). For adults in the high-income stratum, these variables decreased across survey years (cardiovascular risk $\geq 20\%$, 12.0% [95% CI, 10.7%-13.3%] in 1999-2004; 9.5% [95% CI, 8.2%-10.7%] in 2011-2014; $P = .003$; systolic blood pressure, 126.0 [95% CI, 125.0-126.9] mm Hg in 1999-2004; 122.3 [95% CI, 121.3-123.3] mm Hg in 2011-2014; $P < .001$; and smoking, 14.1% [95% CI, 12.0%-16.2%] in 1999-2004; 8.8% [95% CI, 6.6%-11.0%] in 2011-2014; $P = .001$). Trends in the percentage of adults with diabetes and the mean total cholesterol level did not vary by income.

CONCLUSIONS AND RELEVANCE Adults in each socioeconomic stratum have not benefited equally from efforts to control cardiovascular risk factors.

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C ardiovascular disease (CVD) is a leading cause of morbidity and mortality in the United States.[1] Reducing the incidence of CVD is therefore a public health priority and is focused on the management of the leading risk factors for CVD, including hypertension, smoking, diabetes, and elevated cholesterol levels.[2] Although large reductions in CVD risk factors have been achieved in the United States during the past 2 decades,[3-8] it remains unclear whether adults in different socioeconomic strata have benefited equally from this reduction of risk factors.

To our knowledge, only 1 study has compared national trends in CVD risk factor prevalence among adults in different socioeconomic strata.[9] These authors pooled data from nationally representative surveys in the United States between 1971 and 2002 and noted a higher burden of CVD risk factors in lower-socioeconomic groups.[9] Although these findings were important, the analysis is dated, and may not reflect current socioeconomic disparities. Furthermore, the earlier analysis focused on individual CVD risk factors, whereas contemporary guidelines recommend an assessment of absolute cardiovascular risk.[10] The composite effect of changes in the individual risk factors therefore remains unclear.

Accordingly, the primary objective of this study was to assess temporal trends in 10-year predicted absolute cardiovascular risk[11] among adults in 3 socioeconomic strata in the United States: adults with incomes at or below the federal poverty level, middle-income adults, and high-income adults. We also assessed trends in each of the cardiovascular risk factors contributing to cardiovascular risk prediction: systolic blood pressure (SBP), smoking, diabetes, and cholesterol.

Methods

Study Sample

The National Health and Nutrition Examination Survey (NHANES) is a cross-sectional survey conducted by the US National Center for Health Statistics. The survey provides demographic and laboratory data on a representative sample of civilian noninstitutionalized US residents. For the purposes of this study, we obtained and merged publicly available data sets from the NHANES 1999 to 2014 surveys into the following 3 groups: 1999-2004, 2005-2010, and 2011-2014 to allow for sufficient sample sizes within each group.[12] The NHANES procedures were approved by the National Centre for Health Statistics Research Ethics Review Board. Participants provided written informed consent.

Definitions and Measurements

All nonpregnant adults 40 to 79 years of age were included in this study in accordance with the original age limits used to derive the pooled cohort equation (PCE), our selected equation for estimating absolute cardiovascular risk. Participants' demographic details including age, race/ethnicity, sex, insurance status, and educational level were self-reported.

The exposure variable was socioeconomic status, which we assessed based on the family income to poverty ratio (PIR). This ratio reflects annual family income relative to the fed-

Key Points

Question Are there socioeconomic disparities in 10-year predicted absolute cardiovascular disease risk and individual risk factors (systolic blood pressure, smoking, diabetes, and total cholesterol) among US adults?

Findings In this analysis of 17 199 adults without established cardiovascular disease, the percentage of adults with predicted cardiovascular disease risk of 20% or more, mean systolic blood pressure, and the percentage of current smokers declined among adults in the high-income stratum, but there was little evidence of a change among adults with incomes at or below the federal poverty level. The trend in diabetes and cholesterol level did not vary by income.

Meaning Adults in each socioeconomic stratum have not benefited equally from efforts to improve control of cardiovascular risk factors.

eral poverty level, with 1 representing the poverty level, a score below 1 representing incomes below the poverty level, and a score above 1 representing incomes above the poverty level.[9] The PIR is comparable across survey years because income thresholds are updated for inflation each year.[9] We separated participants into 3 groups: adults with incomes at or below the federal poverty level (PIR, ≤1), middle-income adults (PIR, >1 and <4), and high-income adults (PIR, ≥4). We selected the cutoffs for middle- and high-income adults based on the thresholds used in the Patient Protection Affordable Care Act, in which adults with a PIR between 1 and 4 are eligible for insurance subsidies, whereas those with a PIR greater than 4 are not eligible for subsidies. We additionally performed analyses stratified by sex (male and female). We refrained from analyses stratified by race/ethnicity owing to small sample sizes.

The 5 outcome variables were absolute 10-year cardiovascular risk (continuous and binary; <20% vs ≥20%), SBP (continuous), smoking (binary; yes or no), diabetes (binary; yes or no), and total cholesterol level (continuous). Details of the procedure for SBP measurement have been previously described.[13] Similar to past studies, the first SBP measurement was used if only 1 measurement was obtained. Subsequent measurements (second, third, and fourth) were averaged according to NHANES guidelines.[13,14] We did not use a threshold for SBP given uncertainty about the use of SBP targets.[15,16] Furthermore, SBP is included in the PCE as a continuous variable.

Participants with diabetes were identified based on self-report or a hemoglobin A_{1c} level of 6.5% or more (to convert to proportion of total hemoglobin, multiply by 0.01). Current smokers were identified based on self-report. Total cholesterol level was routinely measured in NHANES.

Absolute 10-year risk of cardiovascular events was calculated using the PCE.[11] We excluded participants with a self-reported history of coronary artery disease, angina, acute myocardial infarction, stroke, or congestive heart failure, consistent with the derivation cohort. Medication records provided by NHANES were used to determine whether participants were treated for hypertension. The percentage of adults with a predicted cardiovascular risk of 20% or more and average cardiovascular risk (continuous) were the outcomes of interest.

Table. General Characteristics of Study Participants

Characteristic	Years[a]		
	1999-2004	2005-2010	2011-2014
Study sample, No.	5547	6958	4694
Age, mean, y	53.7 (53.3-54.1)	54.4 (53.9-54.8)	55.2 (54.8-55.5)
Male, %	47.7 (46.2-49.3)	47.2 (46.1-48.3)	47.6 (45.9-49.4)
Race/ethnicity, %			
Non-Hispanic white	77.0 (73.4-80.2)	75.9 (72.4-79.0)	72.1 (66.9-76.7)
Non-Hispanic black	9.1 (7.4-11.1)	9.5 (7.9-11.5)	10.0 (7.7-12.9)
Mexican American	5.1 (3.7-7.0)	3.4 (2.5-4.6)	4.9 (3.4-6.9)
Other Hispanic	5.0 (3.3-7.6)	3.4 (2.5-4.6)	4.9 (3.4-6.9)
Other	3.9 (3.0-5.0)	5.1 (4.1-6.3)	6.9 (5.7-8.3)
Income strata size, No. (%)			
At or below federal poverty level	861 (9.9)	2866 (9.2)	1820 (11.6)
Middle income	1178 (45.8)	3584 (45.5)	2196 (45.2)
High income	909 (44.3)	2348 (45.3)	1437 (43.2)
Insurance, %	88.3 (86.9-89.6)	86.1 (84.3-87.7)	85.2 (83.2-87.0)
College education, %	56.4 (53.8-59.0)	58.4 (55.9-60.9)	65.2 (61.1-69.0)
Predicted absolute cardiovascular risk ≥20%, %	11.5 (10.5-12.7)	10.2 (9.4-11.0)	10.4 (9.2-11.7)
Systolic blood pressure, mean, mm Hg	126.4 (125.5-127.2)	123.7 (123.0-124.3)	124.2 (123.3-125.0)
Diabetes, %	10.1 (9.1-11.2)	11.8 (10.7-13.0)	14.2 (13.0-15.5)
Total cholesterol, mg/dL	211.8 (210.0-213.7)	206.0 (204.3-207.7)	201.5 (199.9-203.0)
Current smoker, %	21.2 (19.7-22.7)	19.5 (17.9-21.3)	18.8 (16.9-20.9)

SI conversion factor: To convert cholesterol to millimoles per liter, multiply by 0.0259.

[a] Continuous variables are provided as the weighted mean and 95% CI. Categorical variables are provided as the weighted percentage and 95% CI.

Statistical Analysis

No variables had more than 10% of values missing; therefore, missing values were treated with casewise deletion, which is unlikely to introduce bias in a complete case analysis.[17] Binary variables were summarized using weighted percentages and 95% CIs. Continuous variables were summarized using means and 95% CIs. Estimates were age standardized to the year 2000 population of adults 40 to 79 years of age without established CVD using the direct standardization method. The percentages used were 0.405 for adults 40 to 49 years of age, 0.272 for adults 50 to 59 years of age, 0.193 for adults 60 to 69 years of age, and 0.130 for adults 70 to 79 years of age.

We examined trends using linear regression or logistic regression as appropriate. The dependent variable was binary for predicted cardiovascular risk (<20% vs ≥20%), presence of diabetes, and current smoking. Mean predicted cardiovascular risk, total cholesterol level, and SBP were assessed as continuous variables. The primary predictor variables were survey year (continuous) and income strata (categorical). The model included adjustment for age, sex, and race/ethnicity (categorical). Sex-stratified analyses were adjusted for age and race/ethnicity. We assessed for an interaction between survey year and income strata. If there was no statistically significant interaction, we examined trends across survey years for all participants, without consideration of income strata. We also examined trends across income strata.

If a statistically significant interaction between income strata and survey year was found, we examined trends across survey years for each income stratum separately. We also assessed pairwise differences between the adults at or below the federal poverty level and high-income adults in each survey

period (1999-2004, 2005-2010, and 2011-2014). We specifically focused on the pairwise comparison between adults at or below the poverty level and high-income adults because we expected that any clinically meaningful differences between groups would be evident from this comparison. Also, this approach avoided the need for adjustment for multiple comparisons if all possible pairwise comparisons were examined.

Finally, given that our study identified a statistically significant interaction between survey year and income strata for predicted cardiovascular risk, SBP, and smoking, we conducted an exploratory analysis in which we included variables for educational level (college vs not college) and health insurance (yes vs no) in the regression model to determine whether the interaction term would remain statistically significant.

Statistical analyses were conducted using Stata, version 14 (StataCorp). Sample weights, which account for oversampling, survey nonresponse, and poststratification, were used to derive all estimates. $P < .05$ was used as the threshold for statistical significance for any tests for interaction or tests for trend.

Results

From 1999 to 2014, NHANES included 17 199 adults who were between 40 and 79 years of age, without established CVD, with a PIR and sufficient laboratory data to calculate absolute CVD risk. The general characteristics of these adults are detailed in the **Table**. The mean (95% CI) age of study participants increased marginally across survey years (1999-2004, 53.7 [53.3-54.1] years; 2005-2010, 54.4 [53.9-54.8] years; and 2011-

Figure 1. Trends in 10-Year Predicted Absolute Cardiovascular Disease (CVD) Risk, Mean Systolic Blood Pressure, and Smoking by Income Strata
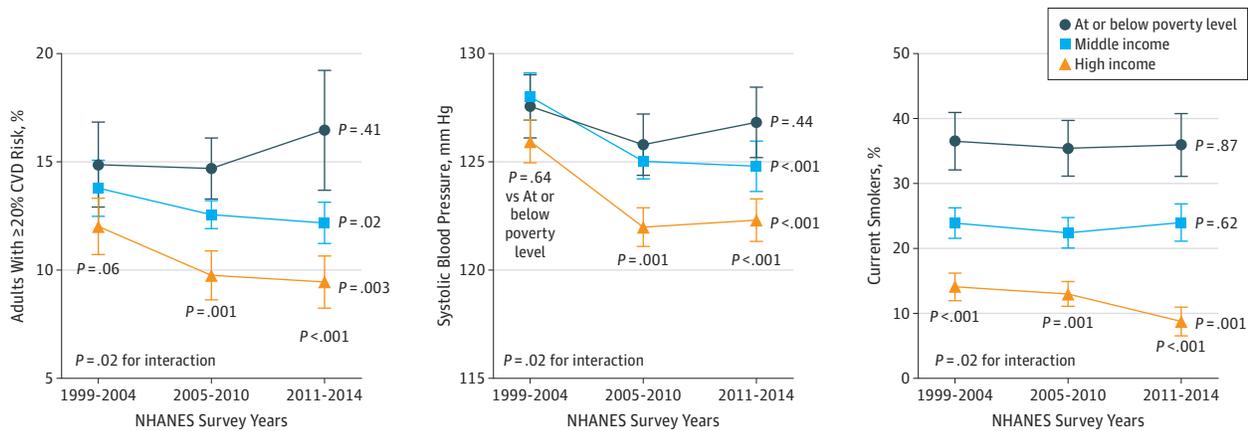
There was a statistically significant interaction between survey year and income strata; therefore, individual tests for trends were conducted for each income group separately and between-group differences were assessed at each survey year. Error bars represent 95% CIs. NHANES indicates National Health and Nutrition Examination Survey.

2014, 55.2 [54.8-55.5] years) and the percentage of non-Hispanic white adults decreased (1999-2004, 77.0%; 2005-2010, 75.9%; and 2011-2014, 72.1%). Finally, the percentage of men and women and the percentage of adults within each income stratum was consistent across survey years.

Ten-Year Predicted Absolute Cardiovascular Risk
Overall, the percentage of adults with predicted cardiovascular risk of 20% or more decreased across survey years (1999-2004, 13.1% [95% CI, 12.3%-14.0%]; 2011-2014, 11.5% [95% CI, 10.6%-12.4%]; *P* = .001) and the trend varied by income strata (*P* = .02 for interaction between high income vs at or below the federal poverty level; **Figure 1** and eTable 1 in the Supplement). Across survey years, there was little evidence of a change in the percentage of adults with cardiovascular risk of 20% or more for those with incomes at or below the federal poverty level (14.9% [95% CI, 12.9%-16.8%] in 1999-2004 to 16.5% [95% CI, 13.7%-19.2%] in 2011-2014; *P* = .41), but there was a decrease for adults in the middle-income stratum (13.8% [95% CI, 12.5%-15.1%] to 12.2% [95% CI, 11.2%-13.1%]; *P* = .02) and the high-income stratum (12.0% [95% CI, 10.7%-13.3%] to 9.5% [95% CI, 8.2%-10.7%]; *P* = .003). In each survey year, the percentage of adults with cardiovascular risk of 20% or greater was lower among high-income adults compared with adults with incomes at or below the federal poverty level.

With respect to analyses stratified by sex, there was a statistically significant interaction for cardiovascular risk across survey years and income strata for men (*P* = .009 for interaction). From 1999 to 2014, there was a small numerical increase in the percentage of men with cardiovascular risk of 20% or greater for those with incomes at or below the federal poverty level (1999-2004, 18.3% [95% CI, 16.0%-20.5%]; 2011-2014, 22.7% [95% CI, 17.2%-28.1%]; *P* = .04; **Figure 2**). In contrast, there was also little evidence of a change for men in the middle-income stratum (1999-2004, 21.1% [95% CI, 19.0%-23.1%]; 2011-2014, 18.6% [95% CI, 16.8%-20.5%]; *P* = .06), but there was a decrease for men in the high-income stratum (1999-

2004, 16.7% [95% CI, 14.3%-19.1%]; 2011-2014, 14.2% [95% CI, 11.9%-16.6%]; *P* = .04). In survey years 2005-2010 and 2011-2014, the percentage of adults with a cardiovascular risk of 20% or greater was lower among high-income men compared with men with incomes at or below the poverty level. For women, there was no statistically significant interaction for predicted cardiovascular risk across survey years and income strata (*P* = .65; Figure 2). However, the percentage of women with a cardiovascular risk of 20% or more decreased across survey years (pooled across all income strata: 1999-2004, 8.7% [95% CI, 7.9%-9.6%]; 2011-2014, 7.1% [95% CI, 6.2%-8.1%]; *P* = .009), and it was inversely associated with income level (pooled across survey years: 5.6% [95% CI, 4.6%-6.5%] in high-income adults; 12.3% [95% CI, 11.0%-13.7%] in adults with incomes at or below the federal poverty level; *P* < .001).

The mean predicted cardiovascular risk (as a continuous variable) decreased across survey years (1999-2004, 9.0% [95% CI, 8.7%-9.2%]; 2011-2014, 8.5% [95% CI, 8.1%-8.7%]; *P* < .001), but the trend did not vary by income strata (*P* = .81 for interaction). With respect to between-group differences, the mean predicted cardiovascular risk was also higher in high-income adults compared with adults with incomes at or below the poverty level (7.7% [95% CI, 7.5%-7.9%] in high-income adults; 10.4% [95% CI, 10.0%-10.8%] in adults with incomes at or below the federal poverty level; *P* < .001). There was no statistically significant interaction for either men or women.

Systolic Blood Pressure
The mean SBP decreased across survey years (1999-2004, 127.0 mm Hg [95% CI, 126.2-127.8]; 2011-2014, 123.9 mm Hg [95% CI, 123.1-124.8]; *P* < .001), and the trend varied by income strata (*P* = .02 for interaction). From 1999 to 2014, there was little evidence of a change in the mean SBP for adults with incomes at or below the federal poverty level (127.6 [95% CI, 126.1-129.0] mm Hg to 126.8 [95% CI, 125.2-128.5] mm Hg; *P* = .44; Figure 1 and eTable 1 in the Supplement), but there was a decrease in the mean SBP for adults in the middle-income stratum (128.0

Figure 2. Trends in 10-Year Predicted Absolute Cardiovascular Disease (CVD) Risk, Mean Systolic Blood Pressure, and Smoking by Income Strata and Sex
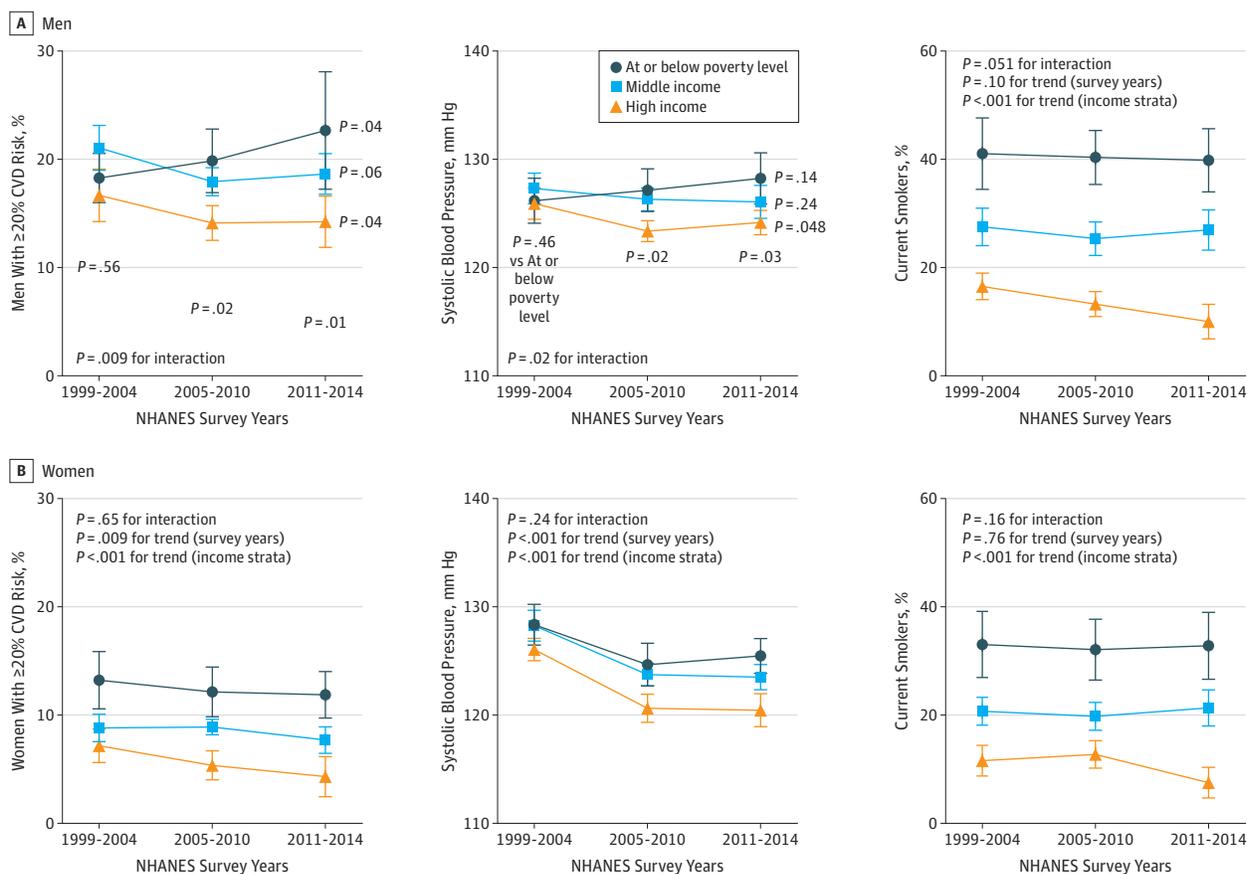
There was a statistically significant interaction between survey year and income strata for the percentage of men with CVD risk of 20% or more. Therefore, individual tests for trends were conducted for each income group separately and between-group differences were assessed at each survey year. Error bars represent 95% CIs. NHANES indicates National Health and Nutrition Examination Survey.

[95% CI, 126.9-129.1] mm Hg to 124.8 [95% CI, 123.6-126.0] mm Hg; $P < .001$) and high-income stratum (126.0 [95% CI, 125.0-126.9] mm Hg to 122.3 [95% CI, 121.3-123.3] mm Hg; $P < .001$). In survey years 2005-2010 and 2011-2014, the mean SBP was lower among high-income adults compared with adults with incomes at or below the poverty level.
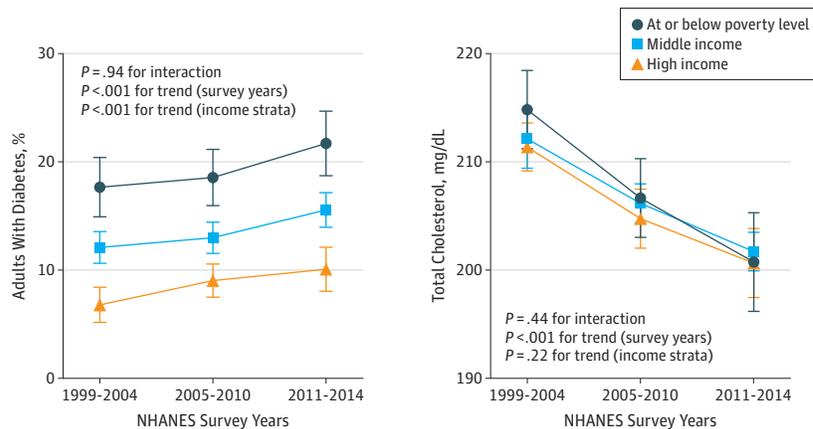
For men, there was a statistically significant interaction for SBP across survey years and income strata ($P = .02$ for interaction). There was little evidence of a change in the mean SBP for men with incomes at or below the poverty level (1999-2004, 126.2 mm Hg [95% CI, 124.1-128.2]; 2011-2014, 128.2 mm Hg [95% CI, 125.9-130.6]; $P = .14$) or middle-income men (1999-2004, 127.3 mm Hg [95% CI, 125.9-128.7]; 2011-2014, 126.1 mm Hg [95% CI, 124.5-127.6 mm Hg]; $P < .001$), but there was a decrease in the mean SBP for men in the high-income stratum (1999-2004, 125.9 mm Hg [95% CI, 124.5-127.4]; 2011-2014, 124.2 mm Hg [95% CI, 123.0-125.3]; $P < .001$; Figure 2). In survey years 2005-2010 and 2011-2014, the mean SBP was lower among high-income men compared with men with incomes at or below the poverty level. There was no statistically significant interaction between survey year and income strata for

women ($P = .24$ for interaction; Figure 2). However, SBP decreased across survey years (pooled across all income strata: 1999-2004, 127.2 mm Hg [95% CI, 126.2-128.1]; 2011-2014, 122.5 mm Hg [95% CI, 121.5-123.4]; $P < .001$), and it was inversely associated with income level for women (pooled across survey years: 122.2 mm Hg [95% CI, 121.4-123.0] in high-income adults; 126.2 mm Hg [95% CI, 125.1-127.2] in adults with incomes at or below the federal poverty level; $P < .001$).

Smoking

Trends in the percentage of current smokers varied by income strata ($P = .02$ for interaction). From 1999 to 2014, there was little evidence of a change in the percentage of current smokers for adults with incomes at or below the federal poverty level (36.5% [95% CI, 32.1%-41.0%] to 36.0% [95% CI, 31.1%-40.8%]; $P = .87$; Figure 1 and eTable 1 in the Supplement). There was also little evidence of a change in the percentage of current smokers for adults in the middle-income stratum (23.9% [95% CI, 21.6%-26.2%] to 24.0% [95% CI, 21.1%-26.9%]; $P = .62$), but there was a decrease for those in the high-income stratum (14.1% [95% CI, 12.0%-16.2%] to 8.8% [95%

Figure 3. Trends in Diabetes and Total Cholesterol Among Adults 40 to 79 Years of Age by Income Strata

There was no statistically significant interaction between survey year and income strata and therefore overall tests for trends were conducted. To convert cholesterol to millimoles per liter, multiply by 0.0259. NHANES indicates National Health and Nutrition Examination Survey.

CI, 6.6%-11.0%]; *P* = .001). Across survey years, the percentage of current smokers was lower among high-income adults compared with adults with incomes at or below the federal poverty level (Figure 1).

For men and women, there was little evidence of a statistically significant interaction for the percentage of current smokers across survey years and income strata (men, *P* = .05 for interaction; women, *P* = .16 for interaction). There was also little evidence of a change in the percentage of current smokers across survey years for men (pooled across all income strata: 1999-2004, 23.6% [95% CI, 21.6%-25.5%]; 2011-2014, 20.7% [95% CI, 18.2%-23.3%]; *P* = .10) and for women (pooled across all income strata: 1999-2004, 18.0% [95% CI, 16.3%-19.8%]; 2011-2014, 16.9% [95% CI, 14.2%-19.7%]; *P* = .76). However, the percentage of current smokers was inversely associated with income level for men (pooled across all income strata: 13.6% [95% CI, 12.0%-15.1%] in high-income men; 41.0% [95% CI, 37.7%-44.3%] in men with incomes at or below the federal poverty level; *P* < .001) and for women (pooled across all income strata: 11.0% [95% CI, 9.4%-12.6%] in high-income women; 32.6% [95% CI, 29.1%-36.2%] in women with incomes at or below the federal poverty level; *P* < .001).

Diabetes and Total Cholesterol

Overall, the percentage of adults with diabetes increased across survey years (**Figure 3** and eTable 1 in the Supplement), but the trend did not vary by income strata (*P* = .94 for interaction). The percentage of adults with diabetes was highest among adults with incomes at or below the poverty level and was lowest among adults in the high-income stratum (Figure 3 and eTable 1 in the Supplement). There was also no statistically significant interaction for either men or women (**Figure 4**).

Likewise, the mean total cholesterol level decreased across survey years (Figure 3 and eTable 1 in the Supplement), but the trend did not vary by income strata (*P* = .44 for interaction). The mean total cholesterol did not vary by income strata (Figure 3 and eTable 1 in the Supplement). There was also no statistically significant interaction for either men or women (Figure 4).

Exploratory Analyses

In exploratory analyses, educational level and health insurance were included in regression models for predicted absolute cardiovascular risk, mean SBP, and percentage of current smokers. The trend in the percentage of these outcomes continued to vary by income strata (*P* ≤ .01 for interaction for both cardiovascular risk and SBP; *P* = .048 for interaction for smoking). The regression coefficients comparing adults in the high-income stratum with adults with incomes at or below the poverty level changed minimally (eTable 2 in the Supplement).
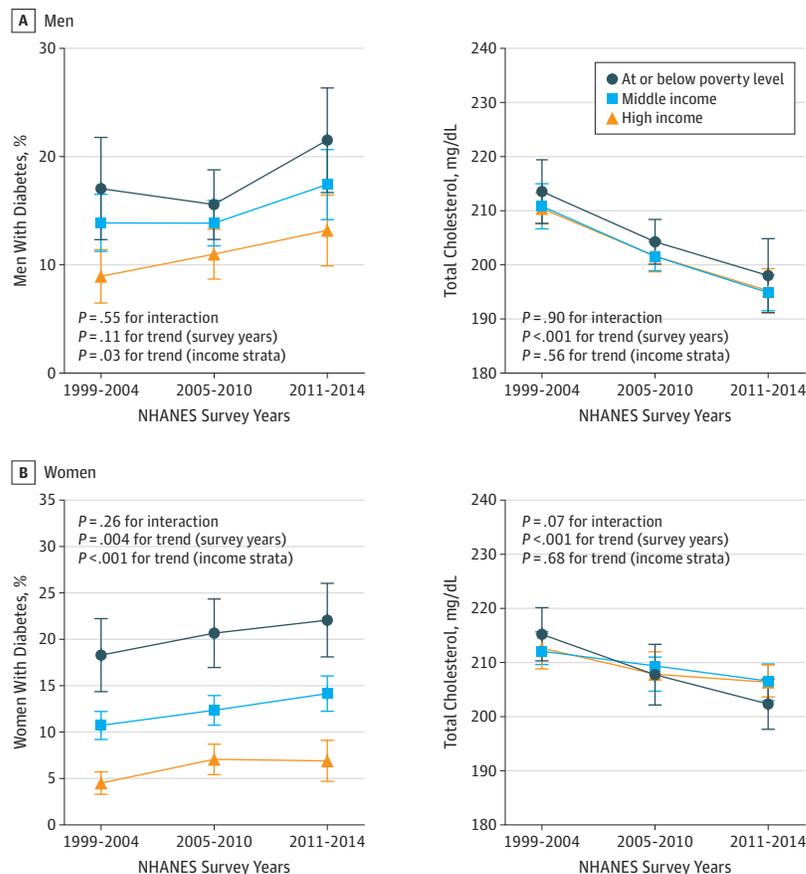
Discussion

This study provides a detailed analysis of income disparities in trends of absolute cardiovascular risk and cardiovascular risk factors among US adults. From 1999 to 2014, we found that the percentage of adults with predicted cardiovascular risk of 20% or greater, mean SBP, and the percentage of current smokers declined in adults in the high-income stratum but remained unchanged in adults with incomes at or below the federal poverty level. The trend in diabetes and cholesterol level did not vary by income. Taken together, recent gains in the control of cardiovascular risk factors in the United States have not benefited adults in all socioeconomic strata equally.

Important shifts in the association between income and mortality have been noted in recent studies of US adults.[18] A large study of 1.4 billion tax records from 1999 to 2014 demonstrated that adults with higher incomes had greater life expectancy and the gap in life expectancy between the richest 5% and the poorest 5% of adults increased over time.[18] There was also county-level variation in the mortality rate among adults in the low-income stratum, which was strongly correlated with smoking rates but not with access to medical care.

Examining trends in cardiovascular risk factors among adults belonging to different socioeconomic strata is therefore an important element of any public health strategy to reduce income disparities in morbidity and mortality. It is well

Figure 4. Trends in Diabetes and Total Cholesterol Among Adults 40 to 79 Years, by Income Strata and Sex

A Men

[Chart: Men With Diabetes, % vs NHANES Survey Years]

Legend:
- At or below poverty level
- Middle income
- High income

P = .55 for interaction
P = .11 for trend (survey years)
P = .03 for trend (income strata)

[Chart: Total Cholesterol, mg/dL vs NHANES Survey Years]

P = .90 for interaction
P <.001 for trend (survey years)
P = .56 for trend (income strata)

B Women

[Chart: Women With Diabetes, % vs NHANES Survey Years]

P = .26 for interaction
P = .004 for trend (survey years)
P <.001 for trend (income strata)

[Chart: Total Cholesterol, mg/dL vs NHANES Survey Years]

P = .07 for interaction
P <.001 for trend (survey years)
P = .68 for trend (income strata)

There was no statistically significant interaction between survey year and income strata; therefore, overall tests for trends were conducted. To convert cholesterol to millimoles per liter, multiply by 0.0259. NHANES indicates National Health and Nutrition Examination Survey.

established that control of cardiovascular risk factors is poorer in adults with lower incomes.[9,19,20] Furthermore, socioeconomic status is associated with cardiovascular events. For instance, Medicare beneficiaries in low-income counties are more likely to be hospitalized for acute myocardial infarction than are those in high-income counties.[21]

However, it is less clear whether the gap in cardiovascular risk among adults in different income strata has changed over time. To our knowledge, only 1 study has compared trends in control of cardiovascular risk factors in adults in high and low socioeconomic strata.[9] In that study, the authors pooled data from nationally representative surveys between 1971 and 2002 and noted that the greatest reduction in hypertension was among adults in the lowest income quartile, whereas the greatest reduction in high cholesterol levels and smoking was among adults in the highest income quartile.[9] However, the composite effect of changes in the individual cardiovascular risk factors remained unclear, as these authors did not assess predicted absolute cardiovascular risk.

Our study expands on this earlier work by examining trends in cardiovascular risk factors and predicted cardiovascular risk using contemporary national surveys (1999-2014). In contrast to the earlier study,[9] we noted a consistent pattern in control of cardiovascular risk factors that largely favored adults in the highest income stratum. We found that the percentage of adults

with predicted cardiovascular risk of 20% or greater, the mean SBP, and the percentage of current smokers declined in adults in the highest income stratum but remained unchanged in adults with incomes at or below the federal poverty level. However, the gap between income strata did not change for diabetes and cholesterol level. Our analysis was stratified by sex, but these results should be interpreted with caution owing to the small sample sizes. Tentatively, our results suggest that the growing disparity in control of cardiovascular risk factors among income strata is most pronounced among men.

Reducing the effects of income disparities in blood pressure management and smoking therefore represent an important focus for population-level interventions. In our exploratory analysis, we found that the interaction term for survey year and income strata remained statistically significant even after the inclusion of adult educational level and health insurance in the regression model. Although this finding suggests that the growing income disparity in SBP and smoking is not completely explained by differences in educational level and health insurance, our analysis may not have captured important nuances about the mediating role of educational level and insurance. For example, the relative performance of insurance plans that enroll adults with lower incomes differs from that of insurance plans that enroll adults with higher incomes, which has been shown to contribute to disparities in

control of hypertension.[8] There are also many other factors that may account for the association between income and SBP, including obesity, exercise, diet, and psychosocial factors.[22] These mediating factors may represent opportunities for preventive interventions to reduce income disparities in control of cardiovascular risk factors.[23]

The prevalence of diabetes increased in all groups examined in our study, a finding consistent with other recent analyses demonstrating an increasing prevalence of diabetes in the overall US population.[24,25] However, an important finding in our study was the marked differences in the prevalence of diabetes in adults belonging to each income stratum. Given that cardiovascular risk has not changed in adults with incomes at or below the federal poverty level, curbing the rise in diabetes in this subgroup is important.

Limitations

Our study has important limitations. First, we performed an analysis of multiple cross-sectional surveys and cannot establish a causal association between income and cardiovascular risk

factors. Second, SBP was measured on 1 occasion only. Third, multiple studies suggest that the PCE may overestimate the risk of CVD.[26] This possibility would have implications for the percentage of adults with a predicted cardiovascular risk of 20% or greater, but would not alter our findings of differential trends based on income strata. Fourth, our study did not examine other important cardiovascular risk factors such as body mass index, glomerular filtration rate, physical activity, and diet. These risk factors were beyond the scope of our study, and body mass index and glomerular filtration rate did not prognostically improve the PCE.[10]

Conclusions

Taken together, recent gains in the control of cardiovascular risk factors in the United States have not benefited adults in all socioeconomic strata equally. Renewed efforts are required to reduce income disparities in control of cardiovascular risk factors.

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